tinyML® Summit

Enabling Ultra-low Power Machine Learning at the Edge

Products and applications enabled by tinyML

March 28 – 29, 2023

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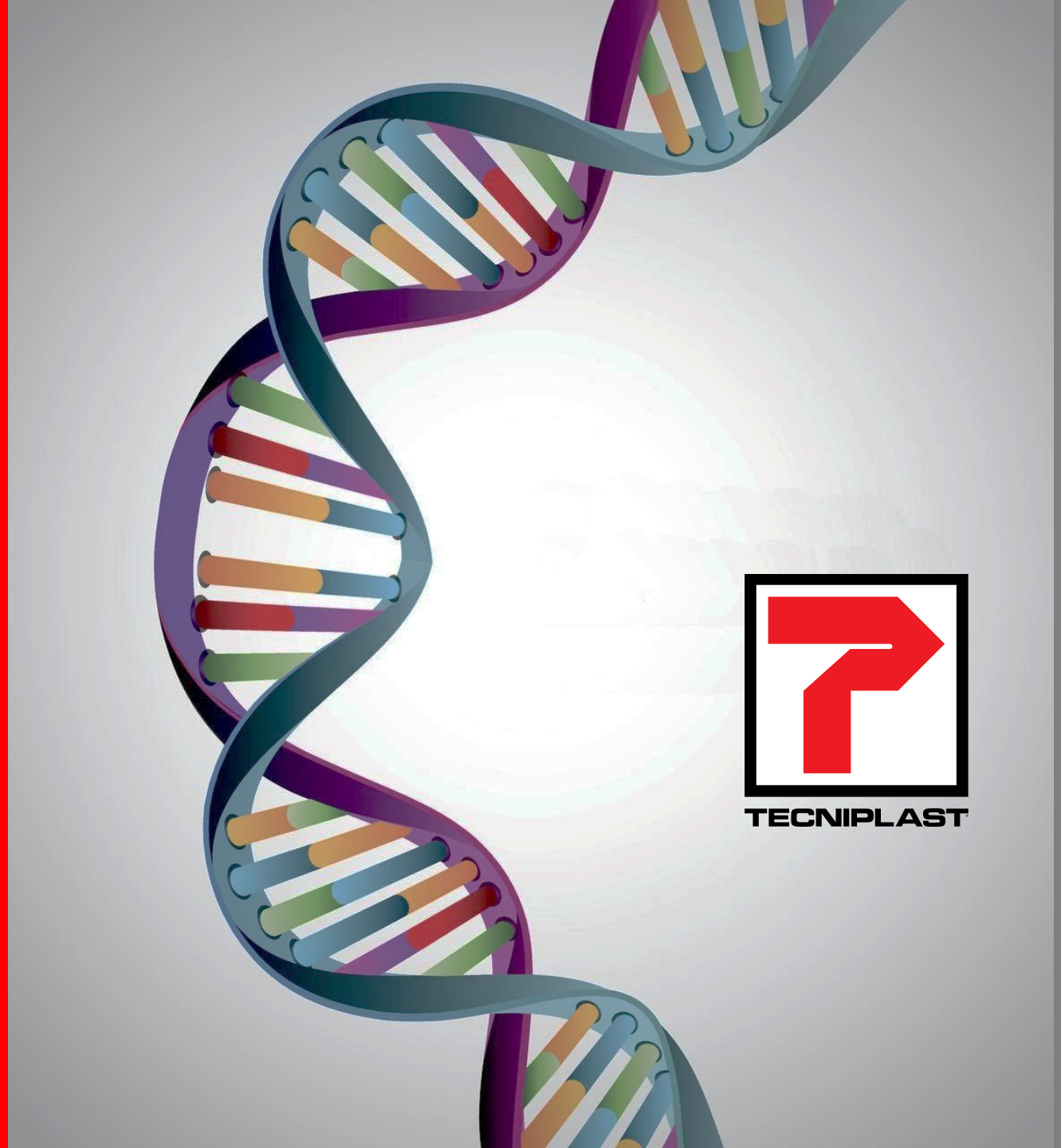


TECNIPLAST

Tecniplast:

End to End MLOp system for pre-clinical medical research

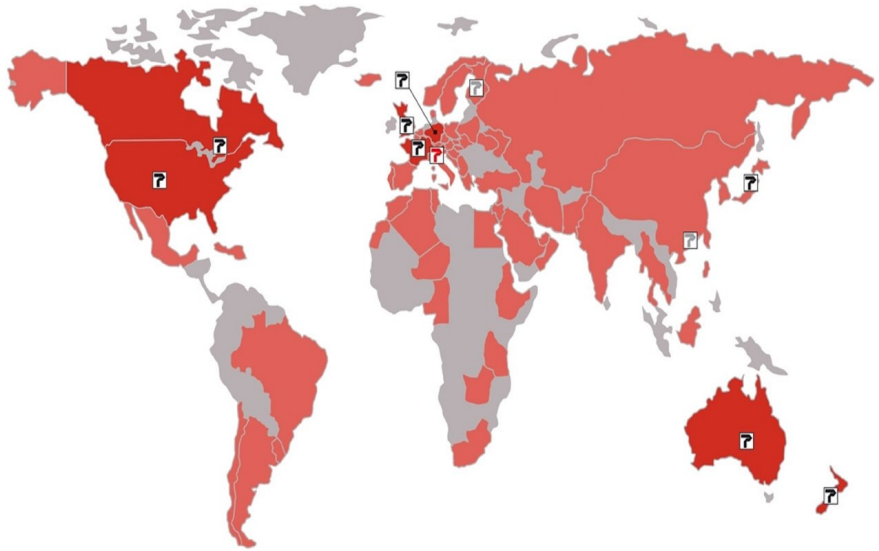
Marco Garzola

TinyML Summit March 27-29 2023

San Francisco

Who is Tecniplast?

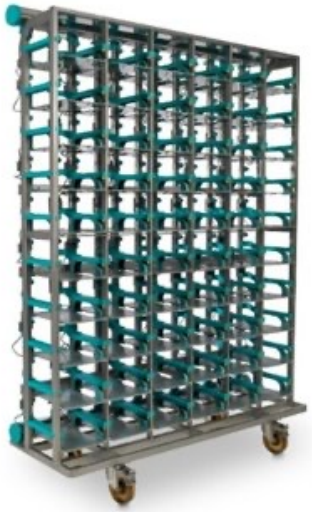
Tecniplast Group is a world-wide leading company in the lab animal industry since 1949. We design, manufacture and distribute equipments for vivaria.
Its core business is the production of special plastic cages for Big Pharma companies and Academia Institutions operating in the pre-clinical industry.



Headquarter,
Buguggiate
(Varese, North Italy)

Some numbers…

- Standard Facility size is between **10K – 20K** cages each



- Currently, Tecniplast sells between 300K and 400K standard IVC cages per year worldwide.

  Only around 10% of cages are currently digital.

- There is a HUGE opportunity to digitalize millions of currently available cages in the field

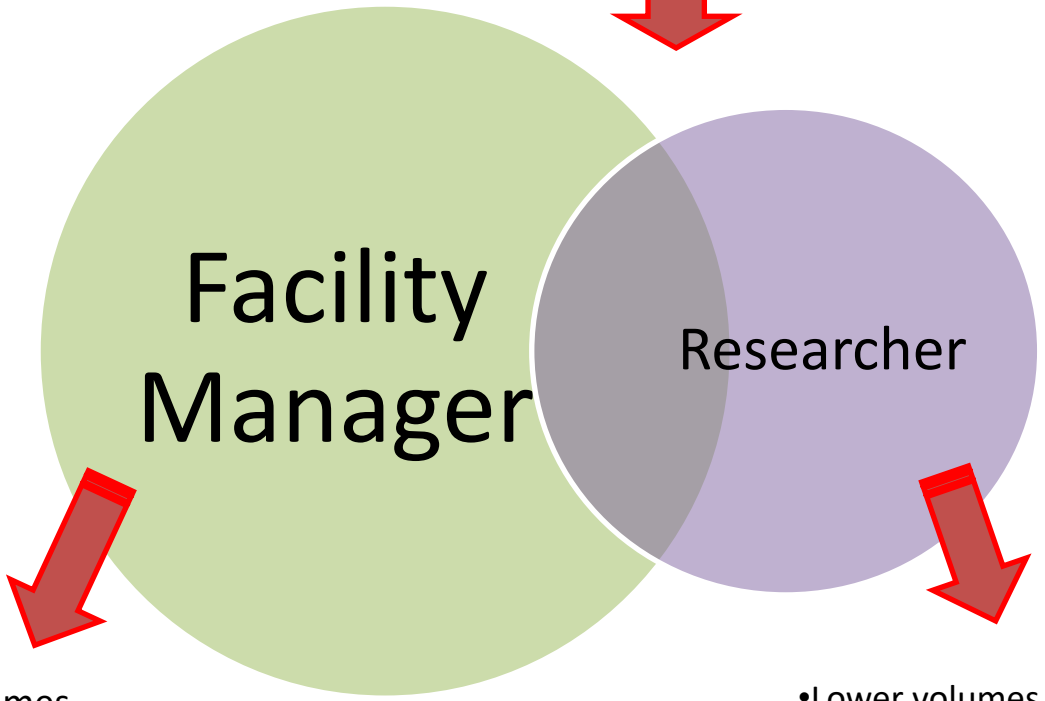
But we do need to be SCALABLE and AFFORDABLE

Market overview

Institutions

Our customers

People



- High Volumes
- Low cost

- Lower volumes
- Higher added value

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Digital targets

Optimize and ease the facility management

Improve the quality of the research

Enhance Animal Welfare

We developed and validated several features, metrics, algorithms, and workflows to reach these targets.

Issues in this market

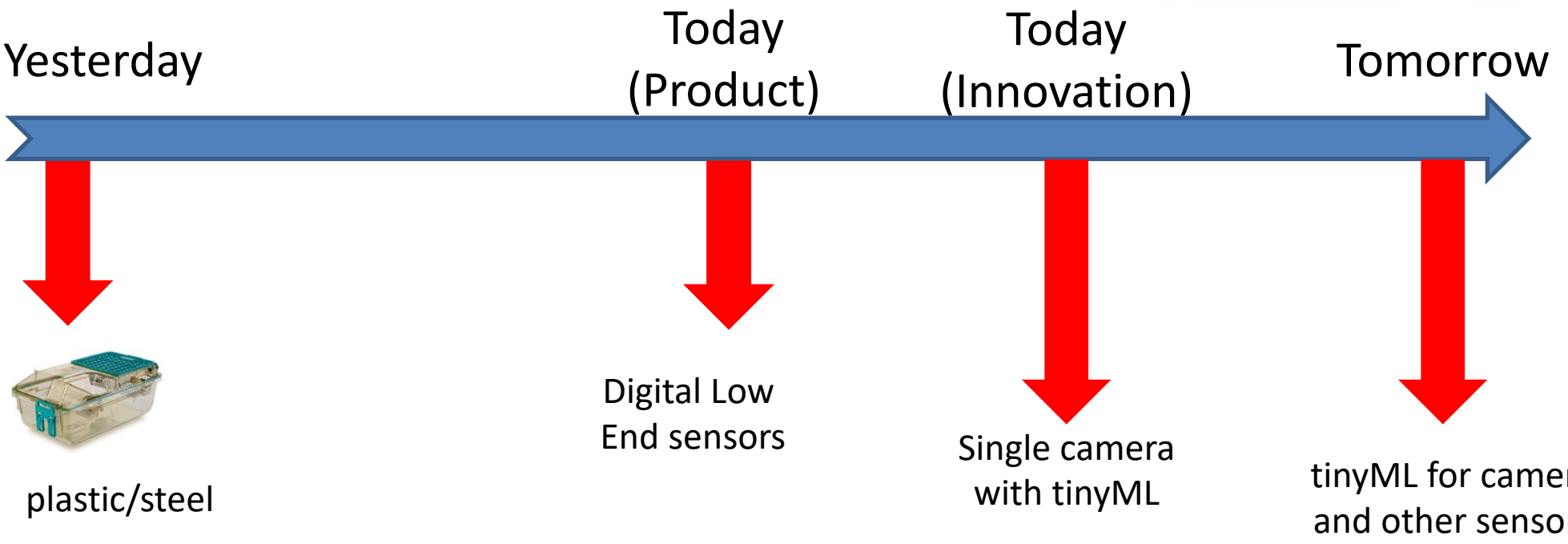
Generic Issues:

- Very conservative market, also today 80% not digital!
- Paper addicted
- Scientific routine doesn't allow to change experimental setup
- Customers NOT willing (nowadays) to spend more on digital equipment

Technical Issues:

- High density devices lead to a low power consumption
- Low cost!

Vision & roadmap



The Innovation team GOAL is to study/integrate/scouting new technologies can lead to innovation into massive production

From pure plastic to intelligent solutions

Current Digital Vivarium Technology (DVC)

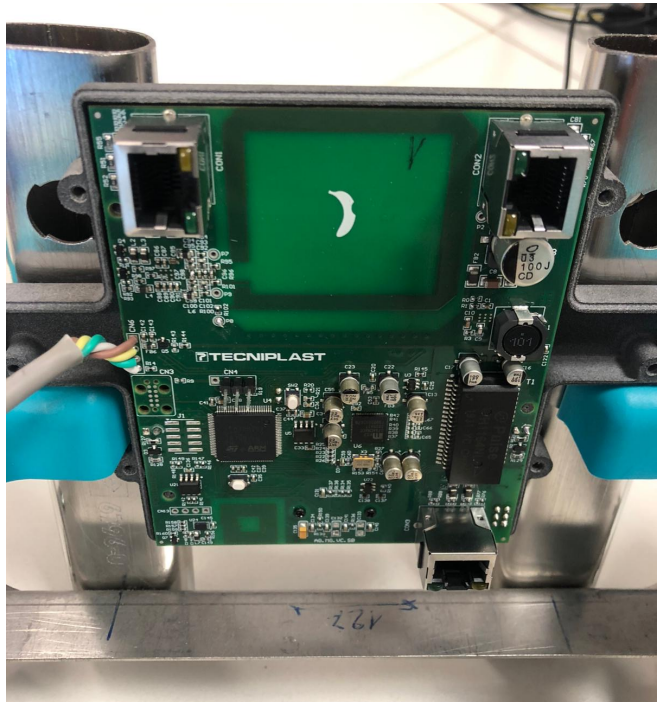
The **DVC®** (Digital Ventilated Cage) is a unique **home-cage monitoring system** designed for standard Tecniplast **mouse IVC cages**, composed of a mix of **electronics**, **software and algorithms** to collect **multiple data 24/7** **directly from the *home cage* while inserted in the *home rack***.

- Based on capacitive sensors
- Able to monitor food/water presence, bedding condition, animals' anomaly detection
- Architecture is based on cloud processing

First evolution of the current product

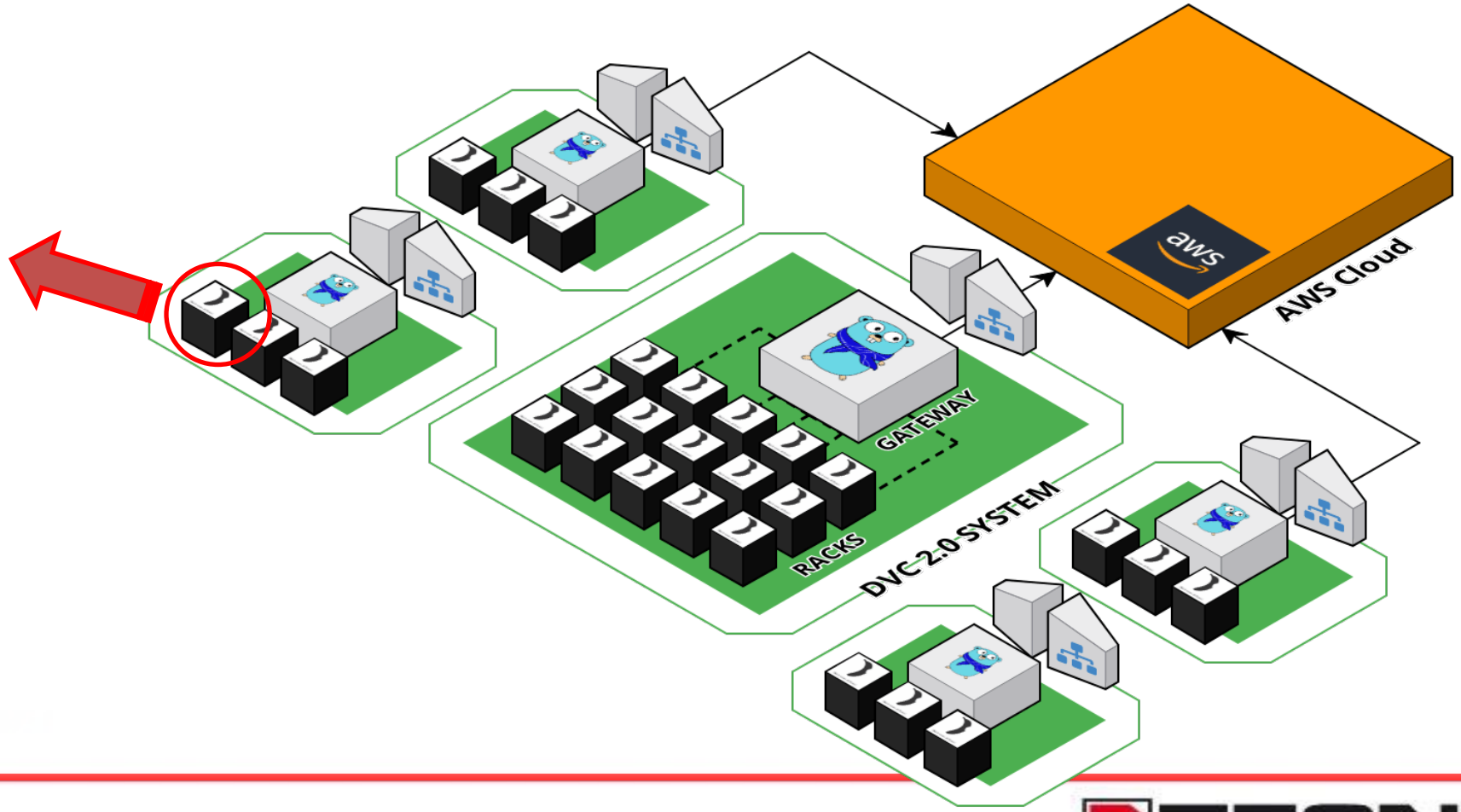
In addition to capacitive sensors, we added a BackBoard capable of Video Streaming 24/7. The mainly goal was to collect data to be processed in the cloud.

- Based on STM32H7 MCUs
- Cost effective for massive production
- Every board integrates an ethernet switch (daisy chain)
- No off-chip RAM used
- Ready to connect to DVC Capacitive Plate
- Low resolution camera 320x240, 4 fps max (mjpeg)



Scalability required

In order to create the proper data-set we needed a scalable architecture



Is the cloud THE solution for this market?

- Cloud is the way to go BUT not for all type of data
- Privacy Issues
- High bandwidth sensors produce huge amount of real time data:

we need to process them locally and to push to the cloud only semantic information

Tecniplast's customer are not willing to pay cloud storage costs for cage' systems: the solution in production shall be scalable and affordable.

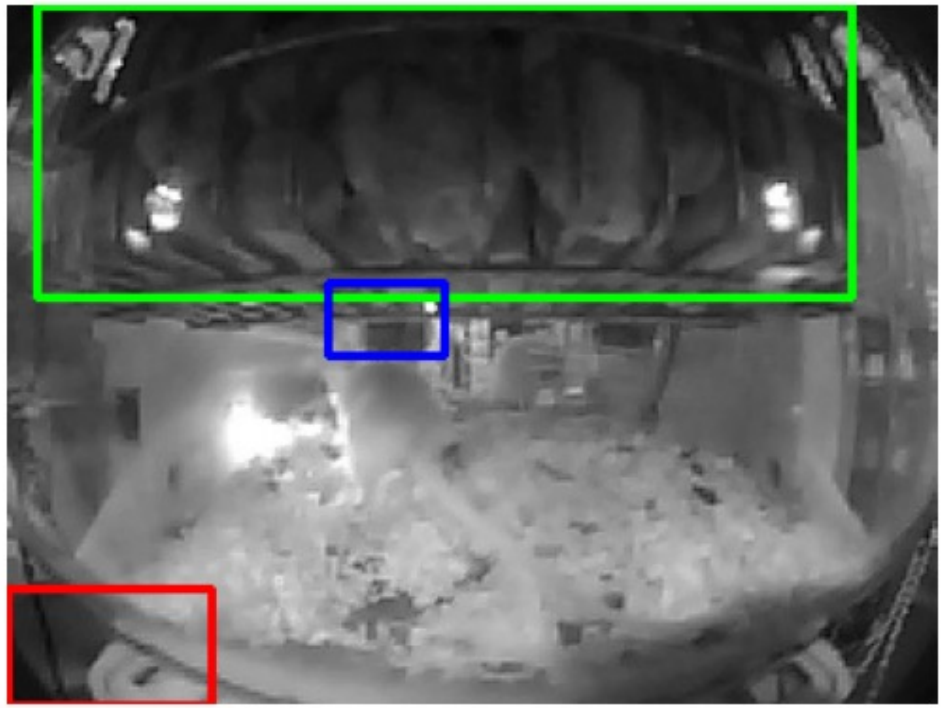
Edge Computing with Machine Learning (Back Board)

life.augmented

Thanks to ST, we integrated Machine Learning on STM32H7 MCUs

Each tiny Neural Network works on sub images to evaluate:

1. Food level (green)
2. Bottle detection (blu)
3. Cage detection (red)



ST/Tecniplast partership

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- HW pre-production prototypes
- Embedded firmware development and integration on STM32H7
- Machine Learning problems definition and requirements
- Dataset acquisition, labelling and cropping

ST

- Design of Keras/fp32, tflite/int8 and QKeras/8-1bits DQNN
- Training and validation
- Knowledge transfer and associated python scripts

Publications

- D. P. Pau, A. Carra, M. Garzola, L. Falaschetti and C. Turchetti, "Complexity bounded classification of fish-eye distorted objects with micro-controllers," 2022 IEEE 21st Mediterranean Electrotechnical Conference (MELECON), Palermo, Italy, 2022, pp. 746-751, doi: 10.1109/MELECON53508.2022.9842897.

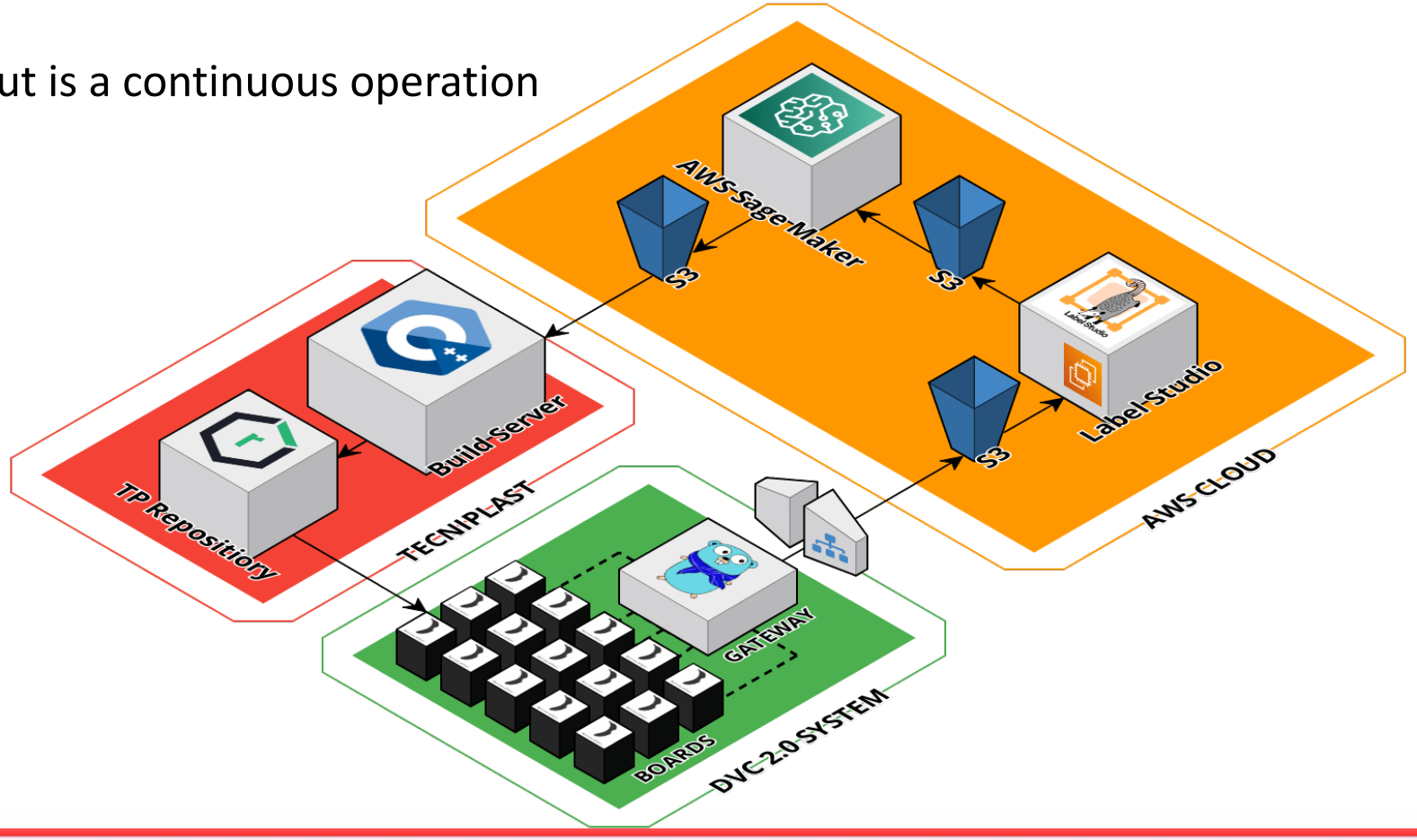
- D. P. Pau, M. R. Dimbiniaina, M. Garzola, A. Carra, "**Deep Tiny Quantization for Fish-Eye Distorted Object Classification**", 2022 2th International Seminar on Machine Learning, Optimization, and Data Science (2022 2th ISMODE).

NN Training process

We have been running experiments with 500 boards under test.

The training process is not a una-tantum but is a continuous operation

How do we train our networks efficiently?

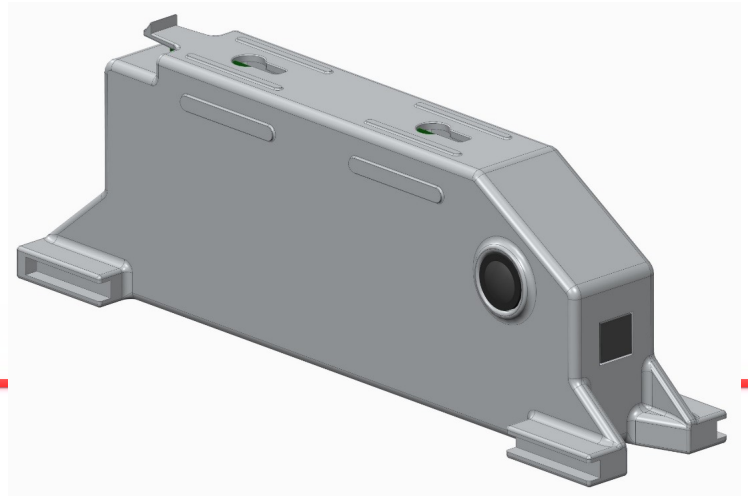


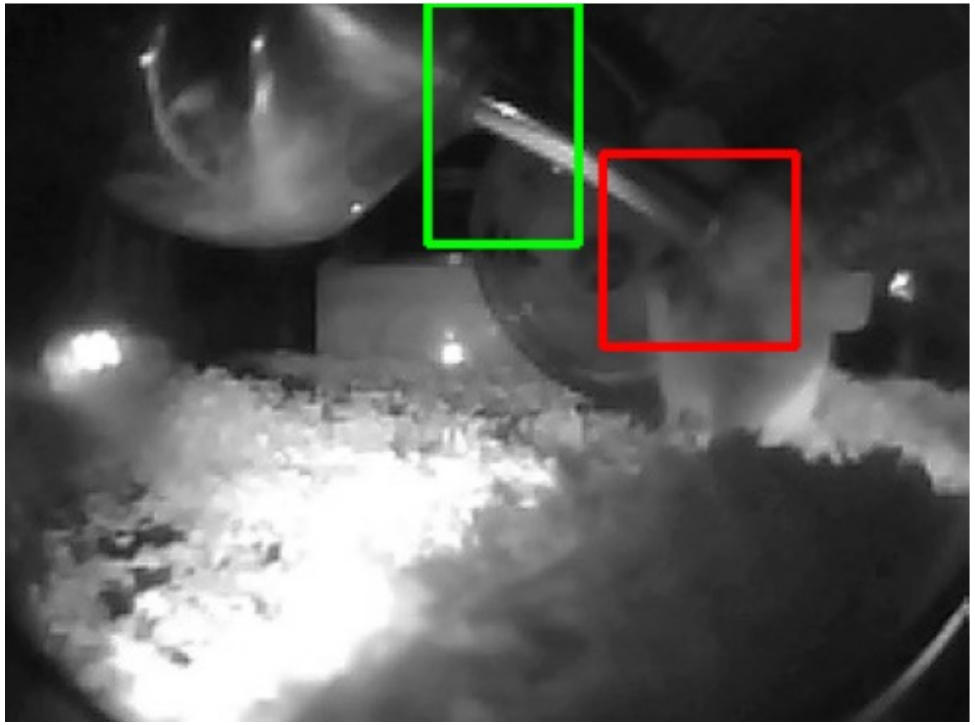
Edge computing with Machine Learning (Side Board)

LaterBoard shares the same technology of back one and with different field of view

Each tiny Neural Network works on sub images to evaluate:

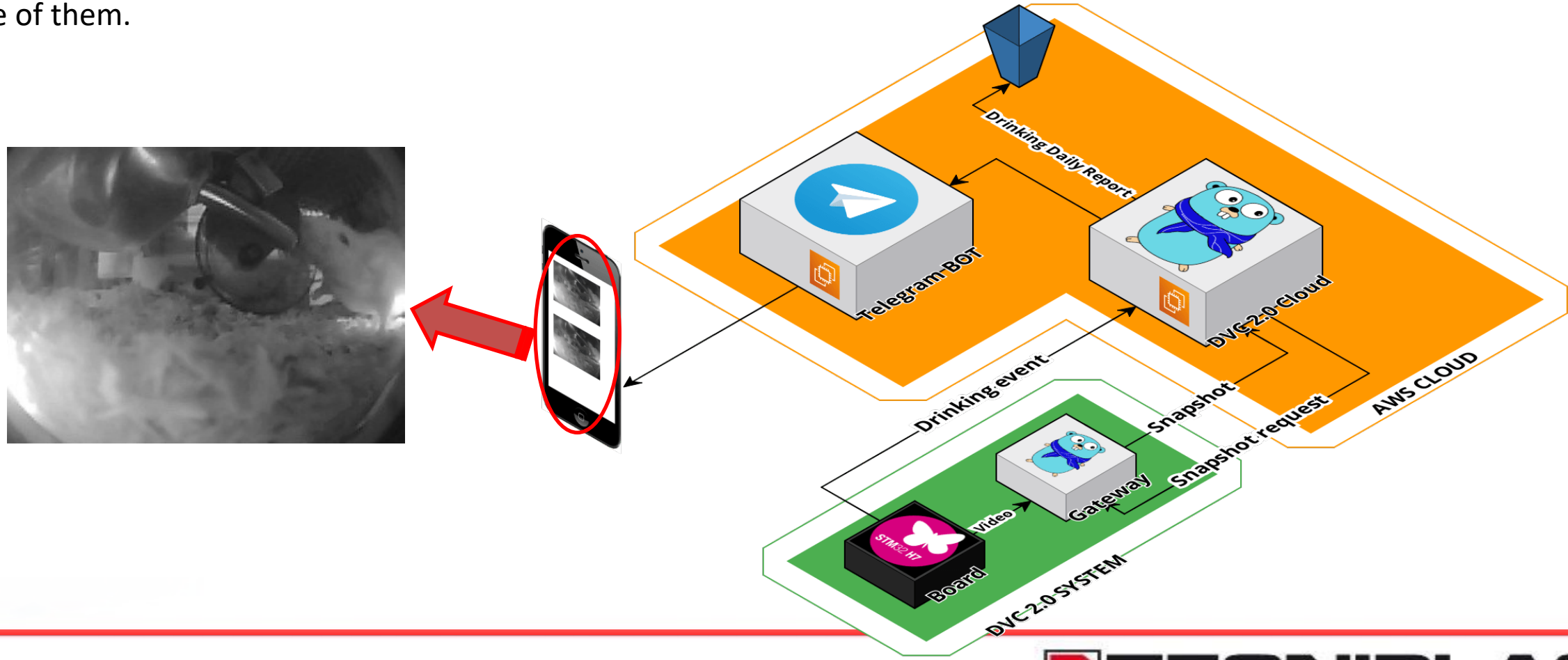
1. Bottle presence (green)
2. Cage detection (green)
3. Mouse drinking (red)





Case Study: mice drinking feature

Because of multiple biological reasons, preclinal research requires to understand mice behavior: how often the mice drink is one of them.



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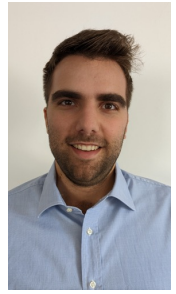
Future development

- In the next future, new tiny ML solutions will be introduced for a wider range of sensors
- Testing microprocessor with HW AI acceleration
- The final goal is to extract behavioral features (posture, feeding, climbing, etc)

Thanks to the Tecniplast/ST joint team



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